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Production Manual for the Great Lakes Region

Moulded Earth Blocks - MEB

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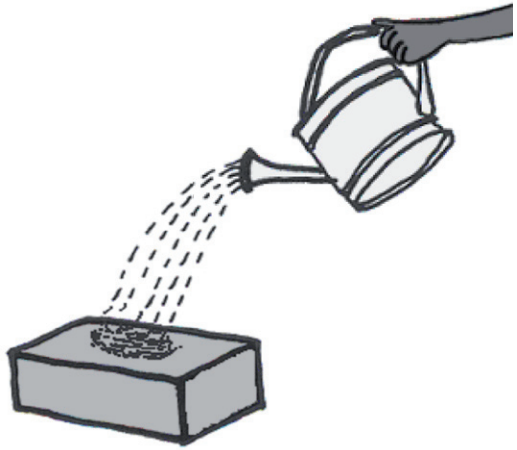
4.4. Simplified erosion test

It is also interesting to perform this test by reproducing soaking / drying cycles. These are the successive cycles, to which are naturally exposed buildings (and therefore blocks), which tend to further accentuate even more the damage.



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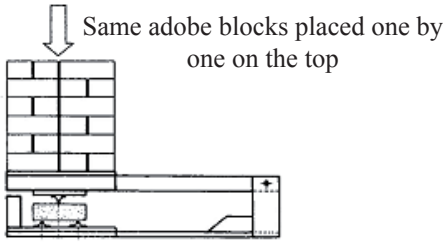
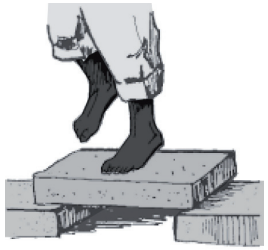
4.3. Simplified strenght test

To control the quality of adobes, choose three random blocks and test them one month after production with the brick-breaker. If they resist to 30 blocks without breaking, quality is satisfactory.



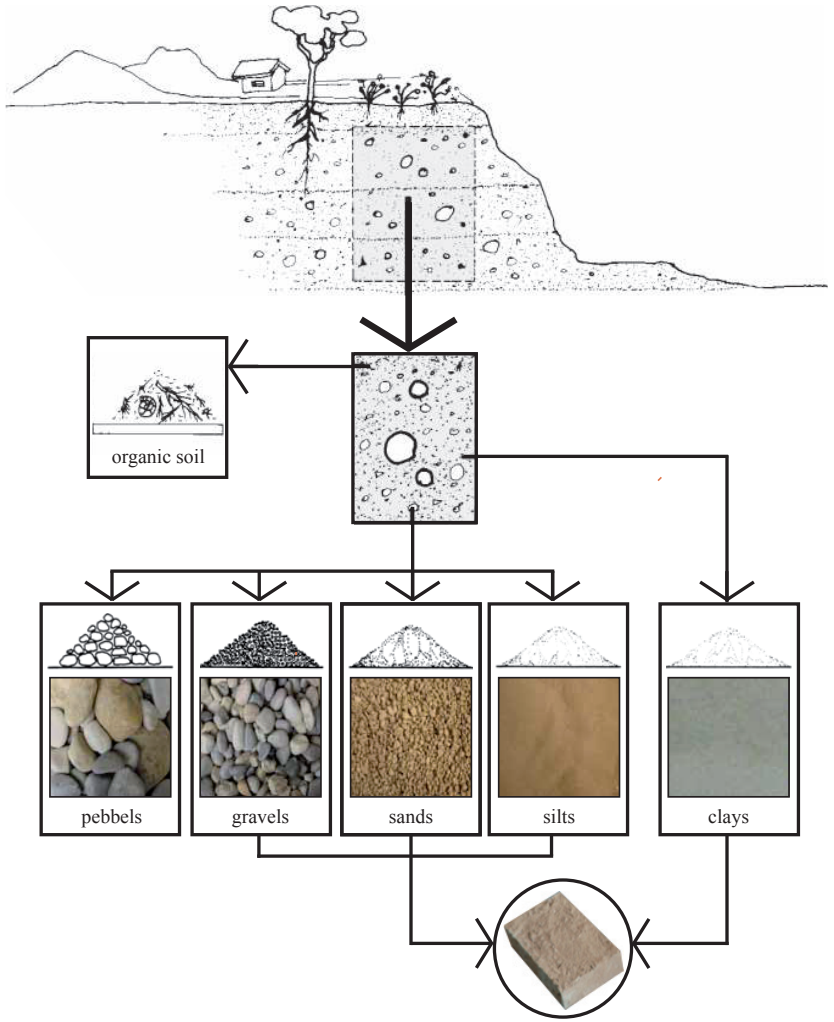
Or simply take a block, put it in balance on supports and go stand on it, if the block can withstand the weight of a man (70 kg), the quality is satisfactory for small structures.



Ultimately, everything depends of the desired strength and the intended use of the adobes.
The one-month period to observe before testing the mechanical strength (period after which the block is the strongest) therefore requires to program the production of stabilized adobe sufficiently in advance of their implementation on site.

Lack of resistance is often due to a lack of cohesion capacity of the earth, taht means a too sandy soil. In this case, change the extraction site.

1.1. Soil constituents



A good adobe soil should consist of clay (15%-18%), silts (10%-28%) and sand (55%-75%), and potantial gravels too. Using organic soil should be avoided (proportion by weight !).

1.2. Soil selection / identification

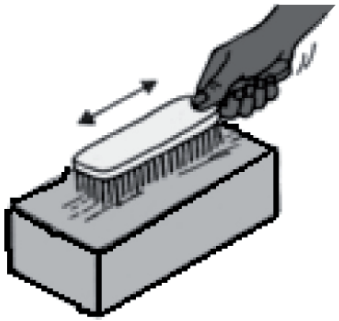
With a solid experience, it is not necessary to practice laboratory tests. Field trials are then often more than enough to understand the behavior and the specific characteristics of soils, so long as diagnostics marks agree. If discrepancies are noticed, further laboratory tests will be mandatory.
In this way it is possible to :
• know how to choose a soil in function of its intended use,
• or, conversely, know how to use optimally soil according to its characteristics.

The soil sample must be representative of the soil that has to be analyzed.
In order to do this, it is necessary :
• to extract very localized samples, that will not be corrected (add or remove elements from it)
• to multiply the samples when the soil is heterogeneous, rather than trying to make an average (which may never be exact).

It is always useful to refer to local knowledge. Information can be gathered by interviewing former masons and elders. It is important to be able to interpret this collected information, particularly through observation of existing buildings.

4.2. Simplified abrasion test

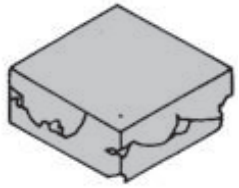
Test made using a wire brush.



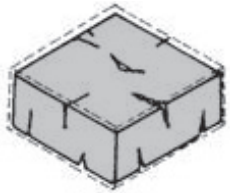
4.1. Shape control

General appearance

No vacuum is accepted at the edges and empty gaps on the side faces are unacceptable : in this case, block need a better filling and compression of the earth along the edges and corners during molding.

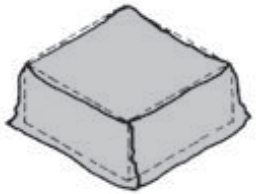


After drying, cracks superior than 5 cm can't be accepted (if so, the soil is too clayey, sand or rather fibers should be added to it).



Schrinkage (dimensions)

The base should not increase by more than 5%.



Tests

Beware : if a sandy soil has little cohesion, and therefore little dry strength, it has the advantage not to crack (minimum withdrawal).
On the other hand, clayey soil has a high cohesion, and therefore high dry strength, but it may crack significantly.

The soil used to produce adobes is enough clayey to ensure natural cohesion of the soil and therefore of the block. Indeed, the clay naturally present in the soil will constitute the only binding agent of the brick.
However, too much clay may cause withdrawal, and therefore significant cracking of the block. In this case, the soil can be corrected and stabilized by adding sand or fibers.

- Smell test :

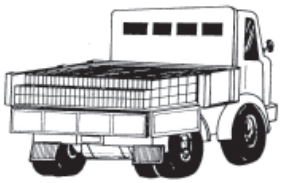
This test consists in smelling wet soil. Smell a moistened quantity of soil. If it has a musty odor, similar of that of wet agricultural soil, it is organic and should be rejected. As the humidification increases, the smell will be more intense.
Recall that the section of organic soil is unsuitable for construction.

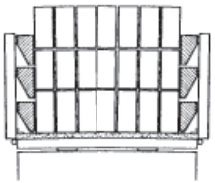
- Preliminary analysis of the texture :

Visual examination :
It initially helps to get an idea of the relationship between large elements, but also of the sandy fraction and the fine fraction (limit of visibility to the naked eye) ; the dominant fraction determines the fundamental properties of the material.

Transport

In order to minimise the damage of Moulded Earth Blocks during transportation :
• spread a layer of sand under the blocks,
• use small wooden wedges to align the adobes against the sides of the truck.
Bricks are stronger if they are transported on the slice.



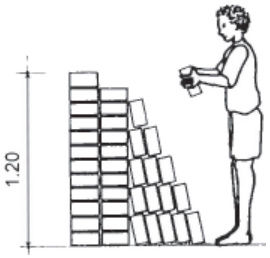


An other choice can be made : to carry the extracted soil and water on the site and produce adobes directly on the construction site to reduce the risk of loss in transit.

Storage

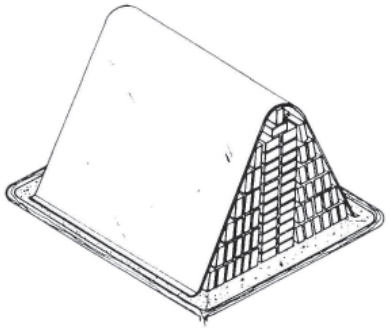
Adobes are thereafter stored well-spaced but not too much in order to finish their drying (complete drying until center of the brick) and optimize the storage space. These storage pyramids take various forms depending on local cultures and habits.

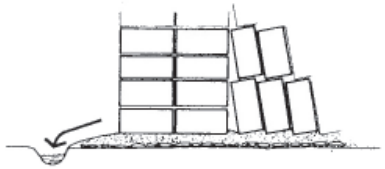
Well aerated storage until the complete drying of the adobes.



Maximum height

Once the bricks are completely dry, if the storage is meant to last in time before use of the blocks, it is possible to further densify the stock by bringing closer the bricks. It may then become useful to cover the stock to protect it (potential shocks, erosion, abrasion, etc..). In this case, care should be taken to place the adobes on a protective insulating layer against capillary rise, and also to dig peripheral ditches to keep away runoff water.





Protective layer of sand with a drain along the periphery.

Touch test* :
- Rough and without cohesion : sandy soil.
- Silky appearance, and once wet moderately plastic : silty soil.
- Presence of resistant and plastic clods, and once wet sticky and malleable : clayey soil.

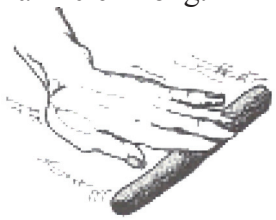
Hand washing test* :
- Easily rinsed off : sandy soil.
- Rest of powder on the skin : silty soil.
- Soapy and difficult to rinse off : clayey soil.

Reminder : to produce a good adobe, part of clay is necessary to act as a link between other grains, but without excess to limit cracks.

** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

- Cohesion Test (cigar test)* :

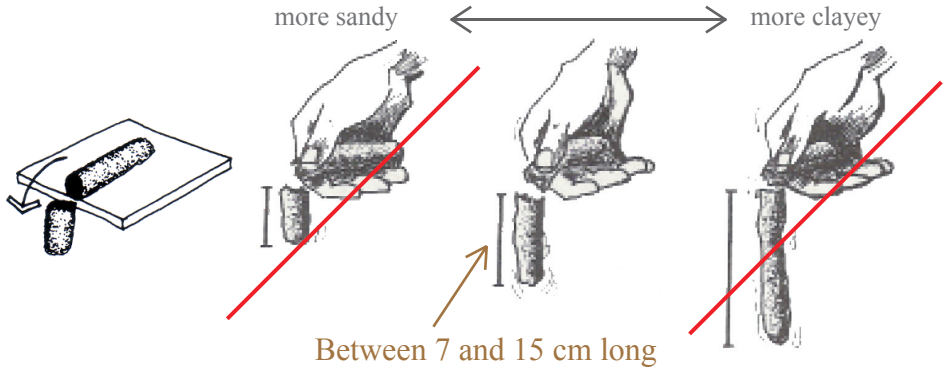
Roll a cigar (not sticky) of 3 cm in diameter (with particles less than 5 mm diameter) and more than 20 cm long.



Then drag it into the vacuum from a flat surface. This test evaluates the clay content in function of the length of the detached portion:

- Short (less than 5 cm) : sandy soil (low soil cohesion).
- Very long (more than 15 cm) : clayey soil (good soil cohesion but significant risk of cracking).

Repeat the test 3 times in order to derive an average.

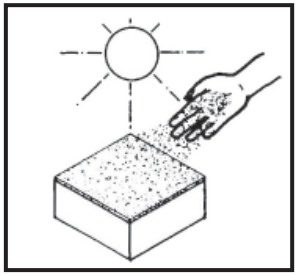


In theory, during the soil identification tests, a soil whose cigar breaks between 7 and 15 cm long is suitable to produce an adobe. Possible cracking can afterwards be corrected by adding amendments. If the cigar would break below 7 cm, the soil would not be enough clayey and therefore cohesive.

** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

Dry curing

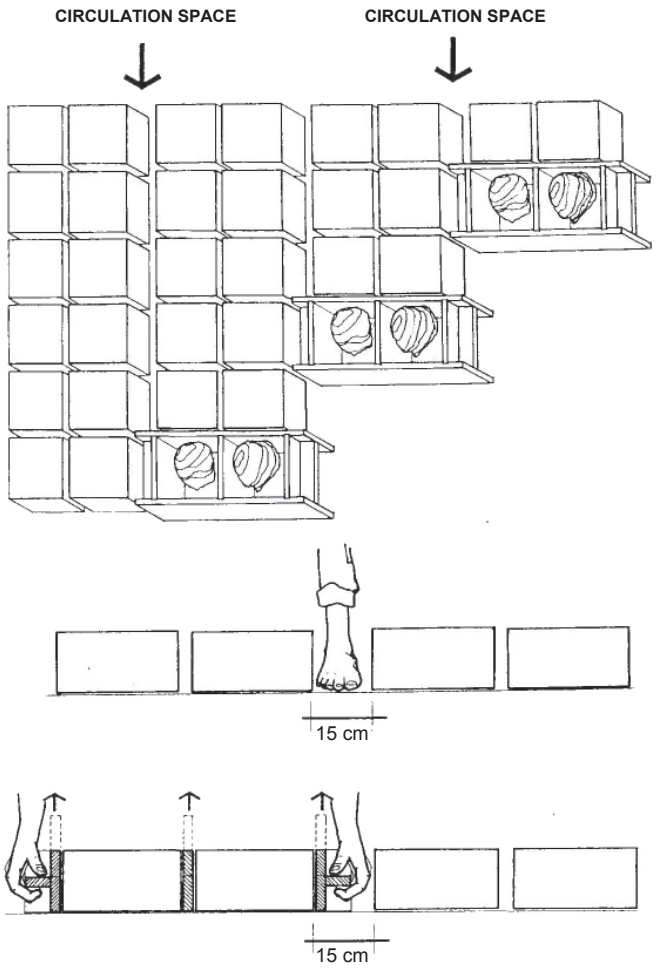
At first, the adobes dry on-the-spot, where they've been demoulded. Sometimes, when the sun is too strong, and may cause too rapid drying and cracking, it may be necessary to provide shade by covering the bricks either by a shelter, or more simply by covering their surface by plants, sand or ash to limit direct sunlight.



Once the adobes can be moved without been deformed (time of varying length depending on the local climate), they are laid on edge, in order to dry all sides of the adobes.

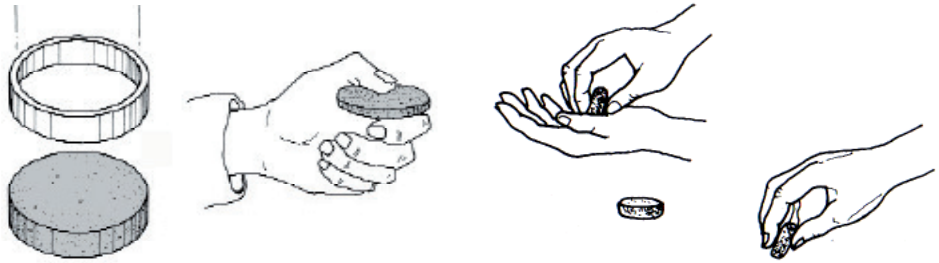
Provide for a circulation passage after every metre to allow for movement to cover the adobes in case of rain

Respect the alignments to better organise the space for efficiency.



- Dry strength test* :

Form a pellet using a ring (from a PVC tube for example).
From made pellets (with the portion of fine particles < 2 mm diameter) that are completely dry : try to crush and pulverize it between the index finger and thumb.

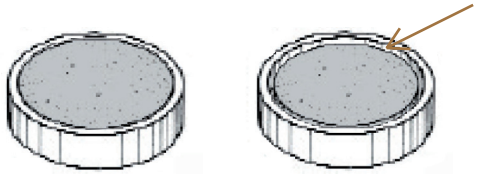


- The pellet breaks easily and reduces itself into powder without difficulty : silt or fine sand, little dry strength.
- The pellet breaks and finally, after some efforts but without too much difficulty, reduces itself into powder : silty clay or sandy clay, average dry strength.
- The pellet is very difficult to break and it is impossible to reduce it into powder : a lot of clay or almost pure clay, high dry strength, but significant risk of cracking.

** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

- Shrinkage test (sun-dried pellet)* :

• Little or no shrinkage and cracking : low clay soil.
• Important shrinkage and cracking : clayey soil.



Reminder : to produce a good adobe, part of clay is necessary to act as a link between other grains, but without excess to limit cracks. Therefore, a small shrinkage is acceptable and can be easily corrected.

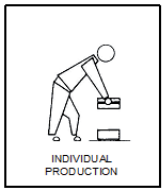
** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

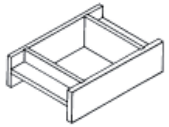
Molding / Unmolding

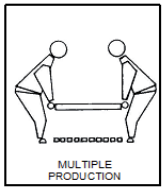
The molding is done on the beforehand prepared production area for this purpose.
Before moulding, it is important to control the optimal water content ; the molding and the block quality depend on it. If the mixture is too dry, the block breaks, if the mixture is too wet, the block deforms.
During the mold filling, firmly tamp down the angles : the angles of a block are always the weakest parts.

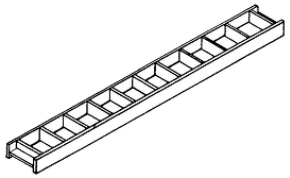
Unmold vertically in order not to deform the brick.

Multiple molds exist and allow the production of several bricks at the same time. However, beyond two bricks at the same time, large molds often require two people to be handled ; the production site has to be large enought and flat to accept multiple ladders.

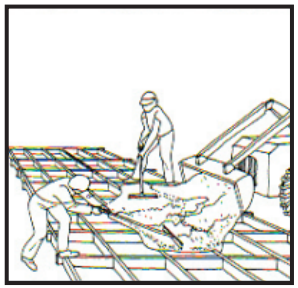


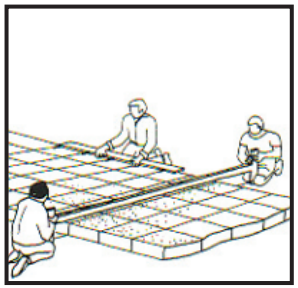


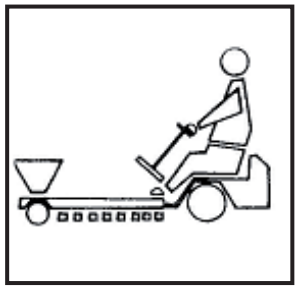




More mechanized systems or automated systems exist in certain contexts.





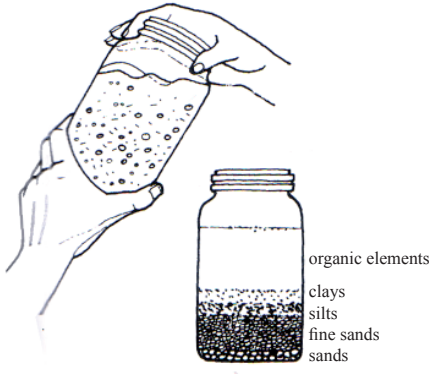


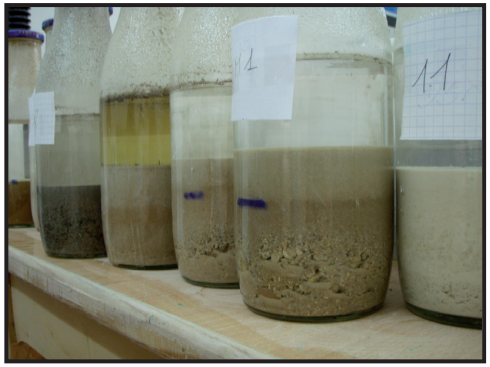
- Sedimentation Test* :

The advantage again is to analyze the percentage of fines present in the earth by comparing superimposed layers of different grains and to check that no expansive clay are in the soil (expansive clay can induce heavy damage and destruction of buildings).

Protocol :

- In glass transparent jars or bottles : have ¼ of the volume of soil (note pitch) and ¾ of clean water,
- let stand for a bit, then shake and decant for 1 h. Shake again and decant during 8 hours,
- measure the total height of sedimentation and observe whether there has been a swelling of soil volume (swelling land) or not,
- then measure the height of each layer to assess the proportion of different grains : sands, silts and clays. If the soil selection is good to produce adobe (the best test to perform is still to produce a brick and control her quality before launching a large-scale production), these measures can constitute a reference throughout production. For that it is important to conserve this « reference bottle ».





** Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.*

more sandy ⟷ more clayey

Before launching a large-scale production, the best test to perform is still to produce a brick (or more with mixtures of different earth) and let it dry to do a quality test and evaluate its behavior. This minimizes the risk of mistake in the choice of raw material and therefore :

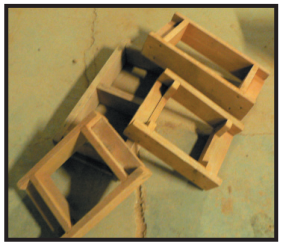
• the loss of blocks in case of too sandy or too clayey soil,
• the poor quality of the items.

Tests done with the finest particles of the soil only (particles ≤ 2 mm) : from the sands to the clays.

Mould and mould preparation

Mould shape differs according to the size and the type of brick to be produced.
The materials used are usually metal or wood.





Before use a wooden mould, soak it in water untill it is fully saturated, in order to the mould do not absorb water from the soil mixture to molding and make it difficult to unmold. Thus it is regularly rewetted between two bricks.

To facilitate the unmolding, it is possible to brush the mould with oil (used car oil for example, but leaves traces on the bricks, so be careful if the brick wall do not have to be plastered). Or sprinkle the mold with sand works well to drag the brick.

Optimal water content (ball test)

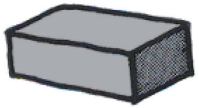
The optimum water content is reached when it is possible to mold and unmold easily the brick without collapsing.
For this, it is possible to perform a small test by vibrating a ball of wet mixture on the palm of his hand.
• if the ball does not deform, the mixture is too dry
• if the ball collapses completely, there is too water in the mixture
• if the ball is deformed without totally collapsing, the water content is correct.


too dry →



too wet →



suitable →


1.3. Soil correction

Soil that doesn't naturally presents the desired characteristics, either because it would be too clayey or not enough (causing many cracks or having insufficient cohesion) can be corrected.

The main way to correct a soil is to change its granularity :
• it is difficult to add clay to a soil that has little cohesion and so resistance, but soil mixtures with different characteristics (sandy soil + clayey soil) can be made in order to obtain a new soil (intermediate),
• on the other hand, it is easily possible to add sand to correct an excess of clay and therefore stabilize the soil, and so cancel cracking.

Cracking of a soil may also be limited by adding animal or vegetal fibers. The use of fiber rather than sand has the advantage of reducing the weight of the soil, while sand makes it heavier and may tend to reduce the quality (strenght) of the bricks.
Traditionally, to improve the characteristics of baked bricks and avoid cracking, brick makers have the habit to mix their soil with different types of natural additives. In order to benefit from this local and often relevant knowhow, it is important to inquire beforehand about these practices using exclusively easily available local elements and abundantly present at lower costs (such as: straw, fonio hay, millet or rice husks, etc.).


2.1. Definition / main characteristics

The adobe or MEB is a molded, naturally dried (unbaked) mud brick. It is an often cheap masonry element, allowing the creation of works of great quality if used in full compliance with the good implementation practices.

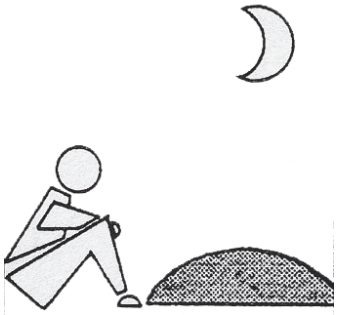
Adobe advantages :
- produced with a easily available and often locally present raw material,
- production doesn't need any fuel supply given that mud bricks dry na-turally in the open air.
- production requires little equipment (tools) and little qualification (tech-nique requiring few training).

On the other hand, the production of adobes requires :
- a lot of water ; the production should be carefully planned according to the water availability periods
- a lot of space ; this should be considered in advance
- a long drying time ; production should be done during adequate weather conditions.

Wet mixing

Add water and mix till obtaining a plastic state (to obtain a soft dough).

To produce traditional adobes (unstabilized blocks), it is better to let the wet mixture rest for at least one night (more if possible) before use,
- to break the agglomerates,
- to allow the start of maceration of the mixture



Dosing and dry mixing

Prepare the mixture on a clean surface and as close as possible to the place of use.
After sieving, to avoid that fine particles are separated from large grains by remaining in the center of the pile; mix the dry sieved soil.

Add to dry earth any useful additives (sand, fibers, etc..). The proportions may vary depending on the nature of the soil and the desired characteristics. To verify the correct dosage between earth and sand or fibers, it is important to perform several « tests bricks » with different dosages and to conduct quality control after production, in order to choose the best one.

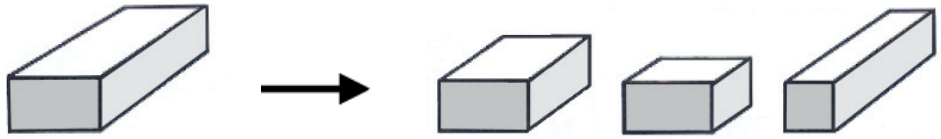
Mix together the dry earth and additives without water, in order to homogenize the whole.
In general, and to obtain a good mixture, it is necessary to move 3 times the whole pile to be sure everything is well homogenized.

2.2. Block types

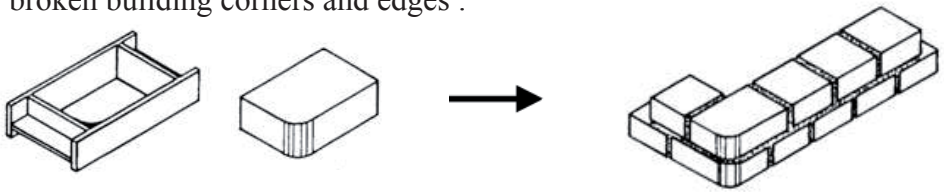
Adobes are blocks, masonry elements whose shape is square or rectangular depending on location (local culture), soils and usages.
A too elongated brick (length ≥ 2 times the width) is more likely to suffer withdrawal therefore susceptible to cracking, while a more square-shaped brick more stable is.

Often the bricks are cut on site to allow good cross joints.

But in case of major construction program, it may be wise to produce blocks whose dimensions are adapted to the size of the building walls and derived from a first basic block (1/2 blocks, 2/3 or 3/4 blocks, etc.), in order to prevent to cut whole moulded earth blocks on site and so to avoid losses (broken blocks) and save time with to facilitating the block work on site.



It is also possible to foresee the production of special blocks : U-shape blocks, rounded blocks, etc...
To realize the wall angles, doorway and window frames, pillars, etc.., which are subject to higher mechanical erosion than other parts of the wall, the anticipated use of rounded blocks can avoid ending up with broken building corners and edges :



Once sized, the production of these special blocks follows the same production steps as for moulded earth blocks described above, only the molds will be different.

Sieving

If the used soil presents grains with a too large diameter that are incompatible with the size of the molds (and elements to produce), it is necessary to sieve the soil (usually 1.5 or 2 cm).

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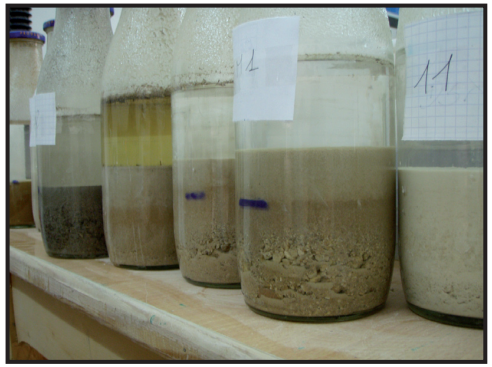
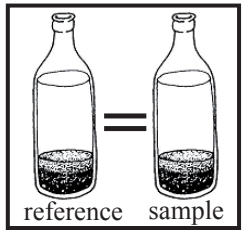
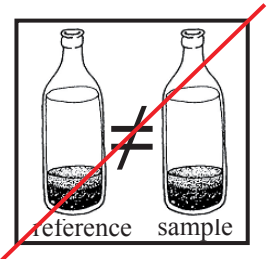
Control of the homogeneity of the raw material

It is important to always check that the extracted earth to produce blocks remains homogeneous throughout the production. Digging deeper or two meters further than the first extraction point, the quality of soil can significantly change.

For that, and for not having to redo every time all the tests to determine the quality of soil, it is possible to reuse the bottle containing the sedimentation test with the selected earth : previously analyzed and considered suitable for its use.
This first bottle serves as a « reference bottle » to compare with the new soils extracted, by making identical bottles regularly carried out from quarry during successive samples. If the the separation of the different layers remains similar, we can deduce that the quality of new extracted soil has not changed and remains suitable to produce adobes.
However, if the 2 bottles do not represent the same characteristics, all the various tests must be repeated to ensure that the new soil is suitable.







3.1. Production organisation

Space

The first thing to ask is where produce ? Two alternatives are possibles :
• on the construction site by transporting earth from the quarry and water,
• or directly to the quarry, with water potentially available nearby (often in ancient flooded lowlands), but implying then transporting bricks to the construction site with a risk of breaking bricks to be taken into account.

Then, to produce blocks, the site must be relatively flat and not sloping.
The production area is determined by :
• the amount and size of blocks to produce,
• the daily productivity,
• the drying time
Indeed, the produced blocks remain on site till they are dried. This requires a large production area.

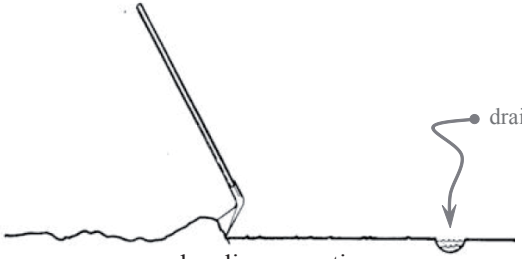
Time

Since moulded earth blocks production requires large amounts of water and sun-drying, it is important to program according to the seasons. That means at the end of the rainy season to take advantage of lowlands full of rainwater and dry weather that allows the bricks drying in the open air without any risk of precipitation.

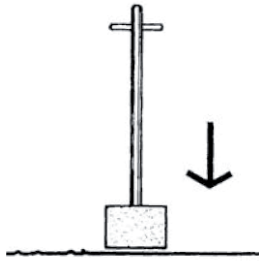
3.2. Production line

Production site preparation

The soil is leveled and compacted to provide a flat surface in order to prevent irregularities :



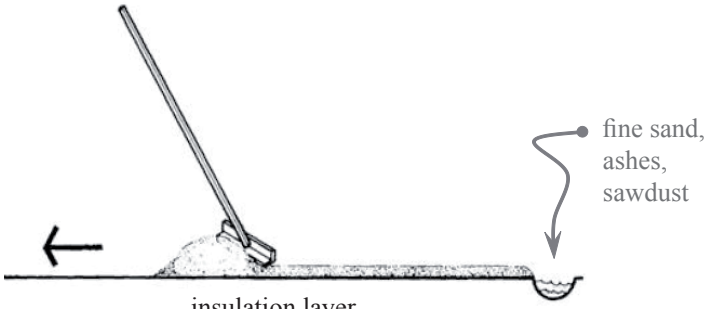
leveling operation



compaction

If necessary, drainage ditches can be dug all around the site in order to redirect and remove any runoff water.

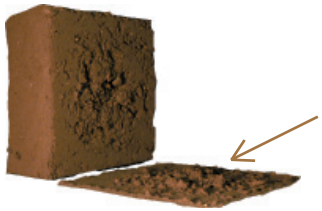
An insulating layer is spread on the entire surface (sand, ashes, sawdust, etc.) so that the moulded blocks do not adhere to the ground :



insulation layer

If the surface isn't well prepared upstream, the risk is :

- to obtain blocks of poor quality with a missing part, in case the block remains glued to the ground,



- having to resize the blocks, if instead a part of the soil stays sticked to the block (generating extra-working time and manpower and thereby extra-costs).